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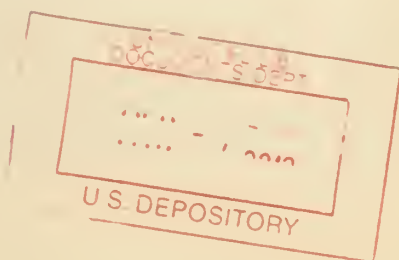
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SPRAYING FOR WHITE FLIES IN FLORIDA.

By W. W. YOTIERS, *Entomological Assistant.*

Citrus trees in Florida are subject to injury by four species of white flies, only two of which, however, the citrus white fly (*Aleyrodes citri* R. & H.) and the cloudy-winged white fly (*Aleyrodes nubifera* Berger), do sufficient damage at the present time to demand remedial measures. Of the two species considered the citrus white fly is by far the most injurious.

THE CITRUS WHITE FLY.

The citrus white fly is an introduced pest, having been brought to this country from Asia some time prior to 1879. Since its introduction it has spread over the entire citrus region of the State and westward throughout the Gulf region. At the present time it infests fully 60 per cent of the groves in Florida. It occurs on some 19 species of trees and shrubs, the most important hosts being the China trees, Cape jessamine, privet, and various species of citrus. Of native plants the only two which have been reported as being seriously infested are the prickly ash and wild persimmon.

LIFE HISTORY AND HABITS.

In completing its life cycle the citrus white fly passes through four stages, viz. egg, larva, pupa, and adult.

The egg.—To the unaided eye the eggs appear as minute particles of whitish dust. They are deposited on the underside of the leaves. To indicate the size of these eggs it has been estimated that 118 placed end to end would measure 1 inch, whereas 1 square inch would contain about 35,164, placed side by side. When examined

under a magnifying glass they resemble kernels of wheat in shape and appear as smooth, polished, greenish-yellow objects. After they are deposited, from 10 to 12 days are required for the eggs to hatch.

The larva.—The newly hatched larva of the white fly is active, resembling that of a scale insect. After crawling for several hours it settles on the underside of a leaf, inserts its beak, and begins to take nourishment by sucking the juices of the plant. To reach the pupal stage it sheds its skin three times, the legs being reduced to mere rudiments after the first molt. The duration of the larval stages is approximately 23 days.

The pupa.—The pupa closely resembles the last-stage larva, but at maturity is thicker, more rounded, with a bright red spot on the back. From 3 to 8 days before emergence the eyes of the adult become visible. The duration of the pupal stage varies from 13 days in the summer to a maximum of 304 days during the fall, winter, and spring. The larvæ and pupæ secrete honeydew, which drops on the leaves and fruit, furnishing nourishment for sooty mold.

The adult.—The winged adults emerge from the pupal cases, which remain attached to the leaves. They collect most abundantly on the new growth and there they deposit their eggs. A single female has been known to deposit as many as 250 eggs, but the average is not more than 150 for each individual. The average life of the adult is 10 days.

Seasonal history.—The citrus white fly passes the winter in the pupal stage, the adults of the first brood appearing in maximum numbers in March or early April, depending upon the season and location. After the practical disappearance of the last brood there is a period of about six weeks when adults are scarce. The second flight, or brood, of adults takes place in June. There is no marked absence of adults between the second and third broods, owing to the overlapping of these broods. The third brood reaches maturity in August, when the third and last flight of adults takes place. The eggs deposited by this third brood develop to the pupal condition and thus they remain on the leaves until the following spring. The third brood is by far the most numerous, and the larvæ and pupæ following this flight, by the extraction of sap and the excretion of honeydew upon which sooty mold grows, cause the greatest damage to citrus trees.

THE CLOUDY-WINGED WHITE FLY.

The cloudy-winged white fly may be distinguished from the citrus white fly as follows: The eggs of the former are dark and have a reticulated surface. Those of the citrus white fly are greenish yellow

and smooth. The pupa case of the cloudy-winged white fly is thin and membranous and collapses after the emergence of the adult, while that of the citrus white fly retains its shape indefinitely. The adults are easily distinguished; the cloudy-winged white fly has dark markings on its wings, while the wings of the citrus white fly are pure white. The broods of the cloudy-winged white fly appear about a month later than those of the citrus white fly.

INJURY FROM WHITE FLIES.

The injury caused by the citrus and cloudy-winged white flies is much greater than is generally supposed. The damage occasioned by the loss of sap is considerable and is a serious drain on the tree, but is of secondary importance to the damage caused by the sooty mold which follows the white fly.

The sooty mold affects both the fruit and leaves, blackening the former and covering the upper surface of the latter with a dark-brown coating which excludes the sunlight and clogs and checks the growth. The reduction in yield from the white flies and sooty mold is variously estimated to be from 25 to 50 per cent.

If the sooty mold forms a coating on the upper half of the orange, the rind underneath it may remain green indefinitely, while the lower half of the fruit becomes well colored. The retardation of ripening, delaying as it does in some cases the time when the fruit is marketable and materially increasing the percentage of culls, causes further loss, which is very conservatively estimated to range from 2 to 5 per cent of the value of the crop.

It is customary to clean fruit noticeably affected with sooty mold. The process of cleaning causes many mechanical injuries which afford entrance to the spores of the blue mold with its resulting decay.

SPRAYING.

White flies may be controlled in two ways: (1) By subjecting the infested plants to the fumes of hydrocyanic-acid gas, or (2) by spraying with a contact insecticide. The latter method only is considered in this paper and has the advantage of being comparatively inexpensive and adapted to grove conditions in Florida.

APPARATUS FOR SPRAYING.

In spraying, an extension rod, varying from 8 to 10 feet in length, should be supplied with each line of hose, the length depending upon the height of the trees. This rod may be an ordinary bamboo pole or a small gas pipe. The former is more suitable for this work in that it is lighter and more easily handled after becoming wet.

A cut-off should always be inserted between the extension rod and the hose. This will enable the operator to cut off the spray at any time, either when going from tree to tree or in order to clean out the nozzle should it become clogged. If a power sprayer is used it is also necessary to insert a cut-off between the hose and pump, which would relieve the pressure on the hose in case of a break. A cut-off inserted at this point also makes it possible for a machine to be fitted with any number of leads of hose which the work may require.

The hose should be from three-eighths to one-half inch in diameter, of the very finest quality, and able to withstand such pressure as the methods of application may require. If a power sprayer is used the hose should be a good quality 7-ply; with reasonable care this will stand up for a season under 150 or 170 pounds pressure. If a barrel pump is used, 4-ply will be sufficient, but even for this the 7-ply is to be preferred and will be found cheaper in the long run. In our experimental work leads of hose 50 feet in length have been found more satisfactory than shorter ones. With long hose both mules and machine may be kept out of range of the spray. Then, too, when using two leads of hose it will be possible, if the hose is long, to progress uninterruptedly on both sides even though there may be a tree missing in one row or the other. In spraying the larger trees long hose is essential in order that the sides of the trees away from the machine may be reached.

To secure satisfactory results the application should be thorough and with sufficient force to break up the liquid into a fine mist. The kind of pump to be used should be governed by the size of the grove and other conditions. A barrel pump will serve every purpose if the trees are low and only a small amount of spraying is required. For larger operations a gasoline-power outfit will give better satisfaction. For Florida such an outfit should be light in weight, with 6-inch tires and an engine of not less than two and one-half horsepower. To keep the machinery free from sand the engine should be provided with canvas curtains.

To obtain satisfactory results it is necessary to have the proper equipment for applying the insecticide. Much of the prejudice against spraying for the control of white flies arises from the inefficient results due to improper equipment.

Since the insects congregate on the underside of the leaves the spray should always be directed upward. To accomplish this one should use a straight nozzle attached to an elbow which makes an angle of approximately 45 degrees or, better still, an angle nozzle which will not get entangled in the foliage and branches. A nozzle which emits the spray in the form of a cone having an angle of about 90 degrees has been found to be very efficient, whereas a flat or solid stream will not give satisfactory results.

HOW TO APPLY THE SPRAY.

In spraying for control of white flies the method of application is the same when using either a barrel pump or a power outfit.

In applying the spray the operator should begin on the far side of the tree and work around to the point nearest the machine. The second half of the tree should be handled in like manner. If two operators are at work on the same tree they should both begin at the point farthest from the machine and proceed until they meet.

The spray should be applied to the tree in a systematic way. The operator should begin at the base and work to the top, inserting the rod among the branches so as to spray the center of the tree. The entire tree may be thus sprayed in sections, the operators proceeding alternately from the bottom to the top and from the top to the bottom. To prevent kinks from appearing in the hose the operator, in moving from tree to tree, should never make a complete turn. In case kinks appear they should be immediately taken out by turning the spray rod and not by pulling the hose.

SPRAY MIXTURE.

It is important that the insecticide used should kill all the insects hit by the spray. Emulsions of various heavy mineral oils have been found to give the best satisfaction. While petroleum fuel oil, or "crude oil," and distillate, or gas oil, will give good results, yet the paraffin oils, known also as lubricating oils, having a specific gravity of from 24° to 28° Baumé have been found to possess certain qualities which make them superior as bases for an insecticide against the white flies. The following formula has given highly satisfactory results:

FORMULA No. 1.

Whale-oil soap.....	8 pounds, or 1 gallon.
Paraffin oil, 24° or 28° Baumé.....	2 gallons.
Water.....	1 gallon.

DIRECTIONS FOR PREPARATION.

In preparing the stock mixture the soap should be put into a receptacle of about 5 gallons' capacity and the oil should then be added very slowly while the mixture is being vigorously stirred. It is important that the oil be added in small quantities at first and also that the stirring be sufficient to keep the oil and soap in the form of an emulsion after each addition of oil. Thus at first about a pint of oil should be added to the soap and the mixture stirred until no free oil appears. As the amount of oil is increased it should always be stirred or mixed thoroughly before the next addition is

made. After the required amount of oil has been added and after free oil has ceased to appear on top of the soap, the water is slowly poured in, about a quart at a time. To determine whether the mixture will form a perfect emulsion add a little of it to soft water, and if no oil floats, the mixture is perfect and may be used for spraying. The presence of floating oil indicates an imperfect mixture and results from adding the oil too suddenly or from insufficient stirring. This condition may be remedied by the addition of more soap, which is preferable to throwing away the entire mixture.

For spraying orange trees use 1 gallon of the stock mixture prepared as just described to 50 gallons of water, or use the entire amount to make 200 gallons of spray material. This dilution contains approximately 1 per cent of oil, which is the maximum strength required for white flies and the purple scale. For three-fourths of 1 per cent of oil add 1 gallon of the stock mixture to 66 gallons of water, and to obtain one-half of 1 per cent add 1 gallon of the stock mixture to 100 gallons of water.

Many alterations may be made in the foregoing formula. The quantity of soap will depend largely upon the time consumed in adding the oil and the amount of stirring accompanying this process. The amount of soap is lessened if the stirring is uniform and if ample time is taken in the preparation. Petroleum fuel oil, or "crude oil," and distillate, or gas oil, may be used instead of the paraffin oil, but in these cases a mixture of about twice the strength will be needed to kill the insects. The amount of water is unimportant, since the emulsion should be perfect if either 1 or 4 quarts be added. The only thing to be remembered is that the diluted spray should contain the required percentage of oil.

The following formula from Farmers' Bulletin No. 172, page 17, has also been found satisfactory:

FORMULA No. 2.

Water (boiling)-----	gallons--	5
Distillate, ¹ 28° Baumé-----	do-----	5
Whale-oil soap-----	pounds--	1½

DIRECTIONS FOR PREPARATION.

Dissolve the soap in hot water and add the distillate, thoroughly emulsifying by means of a pump until a rather heavy creamy-yellowish emulsion is produced. For use against the white fly dilute 1 part of the stock emulsion with 25 parts of water. This dilution will contain about 2 per cent of the oil.

¹ The term "distillate" is commonly given in California to a form of petroleum widely used for spraying purposes.

PROPRIETARY INSECTICIDES.

There are several articles on the market under the head of miscible oils which when properly applied will give satisfactory results. These, however, should not contain sulphuric acid, rosin oil, or carbolic acid.

WHEN TO SPRAY.

So far as the effect of various insecticides on the trees and fruit is concerned it is safe to spray at any season of the year except during the blooming period. If the application is made during the winter, it will be found much more convenient to spray after the removal of the fruit. The insecticide will do no injury to the fruit itself, but its presence on unwashed fruit may prove objectionable to the consumer. It can also be applied during the summer or rainy season, but spring, early fall, or winter applications are preferable in that the beneficial parasitic fungi are not affected by the insecticide during these seasons.

So far as the effect on the various stages of the insects is concerned spraying may be done at any time. The white fly is in the tenderest larval stages about two weeks after the disappearance of the adults of the first brood, and if spraying is done at this period the insecticide can be used at about one-half or three-fourths the usual strength.

The grower should aim to keep the white fly below the point where it will do serious damage, and the number of treatments will depend upon the thoroughness of the work and the abundance of the insects in the grove at the time of spraying. One thorough spraying is much more effective than two or three carelessly applied. The application of the insecticide should be so timed as to be effective in killing the rust mite (*Eriophyes oleivorus* Ashm.) and scale insects as well as the white flies. Experience has shown that two sprayings are sufficient to control the white flies. One of these can be given in the spring, following it by an early fall application, or one can be given during mid-summer and the second during the winter months. The spring and summer sprays are also beneficial in killing the rust mite. Scale insects frequently gain such a foothold as to demand winter treatment, but in some instances one spraying a year has produced clean fruit.

SPRAYING SCALE INSECTS AND THE RUST MITE.

The paraffin-oil emulsion spray when used with 1 per cent of oil will kill the rust mite and its eggs and also the purple scale (*Lepidosaphes beckii* Newm.). It is also effective when used

against the young of the Florida red or "nail-head" scale (*Chrysomphalus aonidum* L.).

EFFECT OF THE OIL SPRAYS ON BENEFICIAL FUNGI.

The experiments so far conducted indicate that the oil sprays do not possess any fungicidal properties, nor do they affect the beneficial parasitic fungi in the least. These fungi develop during the rainy season, while the scale insects, rust mite, and white flies do their greatest damage from September 1 to June 1. The fact that these sprays are applied during seasons when the fungi are inactive is evidence in favor of such remedies in that the increase of the fungi is not directly affected.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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